The Relation between Price and Marginal Cost in U.S. Industry

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An examination of data on output and labor input reveals that some U.S. industries have marginal cost well below price. The conclusion rests on the finding that cyclical variations in labor input are small compared with variations in output. In booms, firms produce substantially more output and sell it for a price that exceeds the costs of the added inputs. The paper documents the disparity between price and marginal cost, where marginal cost is estimated from annual variations in cost. It considers a variety of explanations of the findings that are consistent with competition, but none is found to be completely plausible.

I. Introduction

A competitive firm equates its marginal cost to the market price of its product. The equality of marginal cost and price is a fundamental efficiency condition for the allocation of resources. When the condition holds, the purchasers of the product equate their marginal rates of substitution to the corresponding marginal rates of transformation. By contrast, under monopoly or oligopoly, the allocation of output will be inefficient because price will exceed marginal cost.

This paper derives and applies a method for testing the equality of price and marginal cost. The method is different from the one used in most previous investigations: instead of assuming profit maximiza-

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tion and estimating the slope of the demand schedule (as in the studies surveyed by Bresnahan [in press]), it looks at actual changes in costs. Further, the method makes no parametric assumptions about the cost function. It tests equality of price and marginal cost directly from data on price, output, and the quantities and prices of inputs.

The test developed in this paper rests on the assumption of constant returns to scale. That is, the hypothesis being tested is the joint hypothesis of competition and constant returns. Because competition is inconsistent with increasing returns, it is appropriate to test the two hypotheses together. In order to sustain the interpretation that rejection of the joint hypothesis is unfavorable to the hypothesis of competition, I show that rejection could not have been caused by decreasing returns to scale.

The conclusion from data for seven industry groups is that the joint hypothesis of equality of price and marginal cost and constant returns is strongly rejected for five groups and is rejected at lower levels of significance for the other two. These findings are confirmed for 26 more detailed industries. The paper gives attention to possible specification and data problems that might explain the findings without invoking a failure of competition and constant returns. The problems considered explicitly are measurement errors in labor input from unmeasured fluctuations in effort per hour of work and other sources, errors in measuring output and wages, labor contracts with wage smoothing, adjustment costs, price rigidity, and labor aggregation.

II. Method

The essence of the proposed test is to measure marginal cost as the observed change in cost as output rises or falls from one year to the next. The comparison of movements of inputs with movements in output is at the heart of the calculation. Hence the test is closely related to the measurement of productivity growth. The starting point for the development of the test is a discussion of the properties of a particular productivity measure under the null hypothesis of competition and constant returns. The covariance of measured productivity and an instrumental variable is shown to be zero under the null. Then the value of the same covariance is derived under the alternative hypothesis of market power with constant returns. The covariance must be positive. This discussion is much more fully developed because the productivity literature has not discussed the impact of market power on productivity measurement at any great length. In particular, it is in this section that the relation between measures of marginal cost and measures of productivity growth is developed. Finally, I discuss more briefly why the covariance also will be somewhat positive in the presence of increasing returns to scale.

Characterization of the Null Hypothesis: Competition and Constant Returns

In general, I will be concerned with a firm that produces output Q with a production function $\Theta F(K, N)$ using capital K and labor N as inputs; Θ is an index of Hicks-neutral technical progress. The firm faces a stochastic demand for its output, possibly perfectly elastic. It faces a labor market in which the firm can engage any amount of labor at the same wage, w. Sometime in advance of the realization of demand, the firm chooses a capital stock. I do not assume anything about the market for capital goods, nor, for that matter, do I assume that the firm's investment policy is optimal. However, I do assume that the pure user cost of capital is zero: capital depreciates over time, not in relation to use. I also assume that the firm chooses its labor input so as to maximize profit and that the choice is made after the realization of demand. Finally, I assume that there is at least one observable variable that shifts the demand schedule, the labor supply schedule, or the level of capital used by the firm.

In a famous paper, Solow (1957) derived a relationship involving output growth, product price, capital and labor input, and the wage rate, under the assumptions of competition and constant returns to scale. The relationship is

$$\Delta q_t - \alpha_t \Delta n_t = \theta_t, \tag{1}$$

where Δq is the rate of growth of the output/capital ratio ($\Delta \log[Q/K]$), α is the factor share earned by labor (ratio of compensation wN to total revenue pQ), Δn is the rate of growth of the labor/capital ratio ($\Delta \log[N/K]$), and θ is the rate of Hicks-neutral technical progress ($\Delta \log \Theta$). Solow recommended evaluating the left side in order to measure the rate of growth of productivity. This measure has come to be known as total factor productivity because, unlike measures that consider only output and labor input, it accounts for capital input and, in a more general form, for all other types of inputs.

The statistic on the left side of equation (1) has come to be known as the "Solow residual" and plays a crucial role in the test developed in this paper. The economics of the residual are straightforward. Under competition and constant returns, the observed share of labor is an exact measure of the elasticity of the production function. Without any further restriction on the production function, the elasticity can be read directly from the data on compensation and revenue. Once the elasticity is known, the rate of productivity growth can be obtained simply by subtracting the rate of growth of the labor/capital ratio, adjusted by the elasticity, from the rate of growth of output.

Solow had in mind the calculation of the rate of growth of productivity, θ_t, separately for each year. Because productivity growth seems to have a substantial random element, it is natural to view θ_t as the sum of a constant underlying growth rate, θ, and a random term, u_t. Then equation (1) becomes

$$\Delta q_t - \alpha_t \Delta n_t = \theta + u_t. \tag{2}$$

Now suppose that there is a variable, say Δz_t, that is an important outside determinant of output and employment. It could be government purchases of the output of this industry, or a measure of the shift of labor supply to the industry, or something else that affects Δq and Δn. Suppose further that the variable Δz is exogenous to this equation; that is, it is uncorrelated with the stochastic element of productivity growth, u_t. In other words, the variable Δz is of a type that is known from prior reasoning not to cause shifts in productivity or to be influenced by productivity shifts that come from other sources. Later in the paper I will suggest that the change in military spending is one such variable. If the variable Δz_t has zero correlation with the right side of equation (2), it must have zero correlation with the left side as well. This establishes the following proposition.

PROPOSITION 1. *Invariance of the Solow Residual.*—Under competition and constant returns to scale, the Solow residual is uncorrelated with all variables known neither to be causes of productivity shifts nor to be caused by productivity shifts.

When a convincingly exogenous variable is found to be correlated with the Solow residual, it refutes the joint hypothesis of competition and constant returns. The next step is to investigate the power of the test and the interpretation of rejection. I will demonstrate that, for the case of an instrumental variable Δz that is positively correlated with output and employment, a positive correlation of Δz and the Solow residual is most likely a sign of market power. Increasing returns can also explain a slight positive correlation. Conditions of competition with constant or decreasing returns to scale are incompatible with a positive correlation of the residual and the instrument.

Characterization of the Alternative Hypothesis: Market Power

In order to motivate the discussion of the implications of market power, I will consider the idea of measuring marginal cost and comparing it with price in order to measure market power. The markup ratio—the ratio of price to marginal cost—is a good measure of market power. Consider the problem of measuring marginal cost for a firm with a fixed capital stock and an unchanging technology over time. From one period to the next the change in its labor input is ΔN. A reasonable approximation to its change in labor cost, abstracting from changes in wages, is $w\Delta N$, where w is the current wage. The corresponding change in output is ΔQ. Let x be marginal cost. Then a good measure of marginal cost is

$$x = \frac{w\Delta N}{\Delta Q}. \tag{3}$$

The only element of approximation here arises from the use of finite differences; the corresponding expression in derivatives is exact. It is convenient to rewrite the expression for marginal cost as a relation between the rate of growth of output and the rate of growth of labor input:

$$\frac{\Delta Q}{Q} = \frac{wN}{xQ}\frac{\Delta N}{N}. \tag{4}$$

That is, the rate of growth of output is the factor share, wN/xQ, times the rate of growth of labor input. Recall that in the competitive case considered by Solow, the denominator was revenue. Here it is output valued at marginal cost, xQ. Again, the factor share measures the elasticity of output with respect to input, independent of the form of the technology.

Now let μ be the markup ratio, $\mu = p/x$, and, as before, let α be labor's observed share in revenue. Then the relation between these variables can be written in the earlier notation as

$$\Delta q_t = \mu_t \alpha_t \Delta n_t. \tag{5}$$

Here I have written each of the variables with a time subscript to emphasize that they can change over time. No assumption of constancy of either μ or α is made. In what follows, α_t will always be considered time-series data. Under the null hypothesis of competition, μ has the constant value of one, but there is no assumption of constancy under the alternative hypothesis. Equation (5) holds for any demand function and any technology when the capital stock is constant.

Equation (5) also holds with a slight modification and reinterpretation for a firm whose capital stock varies over time and that enjoys technical progress. The measure of marginal cost that is analogous to equation (3) is

$$x = \frac{w\Delta N + r\Delta K}{\Delta Q - \theta Q}. \tag{6}$$

The change in cost in the numerator now includes a term $r\Delta K$, which is the cost of the change in the capital stock, ΔK, evaluated at the actual service cost of the new capital, r. Alternatively, if the firm is not in equilibrium with respect to its use of capital, r is the shadow value of capital. In any case, r is not the rate of profit calculated as a residual. The denominator in the calculation of marginal cost has an additional term, $-\theta Q$, representing an adjustment for the amount by which output would have risen in the absence of additional capital or labor, assuming that Hicks-neutral technical progress is occurring at rate θ.

Again, it is convenient to rewrite the equation for marginal cost as a relation between the rate of growth of output and the rates of growth of inputs:

$$\frac{\Delta Q}{Q} = \frac{wN}{xQ}\frac{\Delta N}{N} + \frac{rK}{xQ}\frac{\Delta K}{K} + \theta. \tag{7}$$

Unlike its counterpart, equation (4), this relation is not directly usable because the shadow value of capital, r, is not generally observed. Under constant returns to scale, however, it is possible to eliminate r from equation (7). With constant returns, the two shares wN/xQ and rK/xQ are competitive factor shares; that is, they sum to one. Inserting this constraint into equation (7) and rearranging gives

$$\frac{\Delta Q}{Q} - \frac{\Delta K}{K} = \frac{wN}{xQ}\left(\frac{\Delta N}{N} - \frac{\Delta K}{K}\right) + \theta_t. \tag{8}$$

In the notation used earlier, this is

$$\Delta q_t = \mu_t \alpha_t \Delta n_t + \theta_t. \tag{9}$$

Equation (9) expresses the basic idea of the paper. The relation between price and marginal cost can be found by comparing the actual growth in the output/capital ratio with the growth that would be expected given the rate of technical progress and the growth in the labor/capital ratio. The baseline for converting labor growth into output growth is to multiply by labor's share in revenue, α. Under competition, labor's share measures the elasticity of output with respect to labor input. In that case, μ will be one; marginal cost and price will be equal. When marginal cost falls short of price, because firms perceive that raising output to the point of equality will depress the price, then μ will be shown to exceed one. Equation (9) could be used in two ways. First, if the data contain no errors and the rate of technical progress is known, then it can be solved for μ in each year:

$$\mu_t = \frac{\Delta q_t - \theta_t}{\alpha_t \Delta n_t}. \tag{10}$$

Second, in practice the rate of productivity growth will not be known. The statistical model of productivity growth introduced earlier considers it a constant, θ, plus a random disturbance, u_t. Then the Solow residual under market power is

$$\Delta q_t - \alpha_t \Delta n_t = (\mu_t - 1)\alpha_t \Delta n_t + \theta + u_t. \tag{11}$$

The covariance of an instrumental variable with the Solow residual will differ from zero because of the term with $\mu - 1$. This establishes proposition 2.

PROPOSITION 2. In the presence of market power, the covariance of an exogenous instrumental variable Δz and the Solow residual is

$$\text{cov}(\Delta q - \alpha \Delta n, \Delta z) = \text{cov}[(\mu_t - 1)\alpha_t \Delta n, \Delta z]. \tag{12}$$

To simplify the discussion, I will assume, without loss of generality, that the instrument Δz is positively correlated with weighted employment growth, $\alpha \Delta n$. I will argue that it is altogether likely that the covariance of the residual and the instrument is negative or zero under competition and positive only under market power. First, if the markup ratio, μ_t, is a constant, it is immediately apparent that the covariance will be positive if and only if μ exceeds one. Second, the validity of the test based on the covariance extends to cases of variable markup ratios. In particular, if the markup varies along with the instrument in a linear fashion, if weighted employment growth also varies linearly with the instrument, as follows:

$$\mu_t - 1 = a + b\Delta z, \tag{13}$$

$$\alpha \Delta n = c + d\Delta z, \tag{14}$$

and if the instrument is distributed symmetrically around a zero mean with variance σ^2, then the covariance is

$$\text{cov}(\Delta q - \alpha \Delta n, \Delta z) = (bc + ad)\sigma^2. \tag{15}$$

Here I have assumed that the first and third moments of Δz are zero. By hypothesis, d is positive because employment is positively correlated with the instrument. If competition prevailed on the average, then a would be zero since it is the mean of $\mu - 1$. The parameter c is the average growth rate of the labor/capital ratio and is slightly negative in all cases. If the markup ratio were positively related to the instrument ($b > 0$), then the covariance would be slightly negative under competition. The only possibility of a false rejection would occur if the rate of growth of the labor/capital ratio were quite negative ($c < 0$) and the markup ratio were strongly negatively related to the instrument ($b < 0$). With market power, the term ad would be positive and the test would reject competition unless the bc term were negative enough to offset ad.

To summarize, the covariance of the Solow residual with the instrument will be close to zero under competition and positive under market power. The only qualifications are that the covariance could be slightly positive under competition if the average growth rate of the labor/capital ratio were very negative and the markup were strongly negatively correlated with the instrument, and that the covariance could be zero or negative under market power if the markup were strongly positively correlated with the instrument.

The proposed test rests on the simple proposition that, to the extent that the firm is noncompetitive, its measured productivity will be associated with its rate of growth of labor input over fluctuations associated with an exogenous instrument. When productivity rises along with employment in response to an outside force, it is a sign that the firm is not competitive.

Example 1: Overhead Labor

An example will demonstrate how the method deals with a technology that seems to describe a number of important U.S. industries. A firm has capacity K. In order to produce any output at all, it must hire λK overhead workers. In addition, for each unit of output, it must hire ϕ workers. Thus to produce a level of output Q, it must have a K at least as large as Q and employment of $\lambda K + \phi Q$. The firm's marginal cost is $w\phi$ whenever $Q < K$ and can be taken to be any number above $w\phi$ when the capacity constraint is binding. In competitive equilibrium, $p = w\phi$ whenever $Q < K$ and $p \geq w\phi$ whenever $Q = K$. Note that the technology has constant returns to scale (the fixed component of labor is proportional to capacity, not absolutely fixed), so a competitive equilibrium is possible. Now consider the measurements proposed in this paper for a period in which output is below capacity. Labor's share will be

$$\alpha = \frac{wN}{pQ} = \frac{w(\phi Q + \lambda K)}{\phi w Q}. \tag{16}$$

Because the competitive firm operates at a loss whenever its output is below capacity, the share exceeds one. The Solow residual is

$$\begin{aligned} \Delta q - \alpha \Delta n &= \frac{\Delta Q}{Q} - \alpha \frac{\Delta N}{N} \\ &= \frac{\Delta Q}{Q} - \frac{w(\phi Q + \lambda K)}{\phi w Q} \frac{\phi \Delta Q}{\phi Q + \lambda K} \\ &= 0. \end{aligned} \tag{17}$$

Thus the Solow residual remains unchanged when an outside force alters the levels of output and employment. The covariance of the Solow residual and an exogenous instrument is zero, and the proposed test will reveal, correctly, that the firm is competitive. Even though the variation in labor input itself may be very small because most workers are overhead workers, the competitive value of α exceeds one by enough to make $\alpha\Delta n$ equal Δq. The mere existence of overhead labor does not lead to the rejection of competition.

In practice, for those industries that appear to have large overhead labor requirements and small variable labor requirements, the behavior of the labor share α and the resulting covariance of the Solow residual and an instrument are not at all what is described by the competitive model just summarized. Rather, when such an industry operates below capacity, its price remains far above the cost of the variable component of labor. Profit often remains positive, so labor's share, α, is less than one. The ratio of Δq to $\alpha\Delta n$ is, say, three, not one. The appropriate conclusion is that price is three times marginal cost, and the firm is far from competitive. The Solow residual rises sharply whenever an outside force causes employment and output to rise.

Example 2: Labor Hoarding

The most widely advocated explanation of the positive correlation of output and productivity is that firms carry workers through slumps because discharging them would dissipate the value of their job-specific human capital. In a simple version of the labor-hoarding model, the firm would lay off only $\phi\Delta Q$ of its workers if a slump caused by adverse external developments caused output to fall by ΔQ. Additional workers would be kept on even though they were idle. The economics are then identical to the first example. Marginal cost is $w\phi$ and the competitive price should fall to this level. Then α will be well above one, so that the Solow residual is invariant to a shift in employment and output, even though the change in output is much larger than the change in employment. However, if the firm is not competitive so that price does not fall enough to make α large, then the Solow residual will rise when an outside force raises employment and output.

Characterization of the Alternative Hypothesis: Increasing Returns

The preceding discussion considered the behavior of the test under constant returns to scale. This subsection considers departures from that assumption. Going back to equation (7) and restating without the assumption of constant returns but assuming competition, I get

$$\Delta q - \alpha\Delta n = (\alpha + \beta - 1)\Delta k + \theta. \tag{18}$$

Here β is capital's factor share, rK/pQ, and Δk is the rate of growth of the capital stock. Note that this reduces to equation (1) under constant returns, where $\alpha + \beta = 1$. It is reasonable to suppose that an instrumental variable that was positively correlated with employment and output growth would also be positively correlated with the growth of capital. Under this assumption, it is apparent from equation (18) that the covariance of an instrument with the Solow residual will be positive under increasing returns ($\alpha + \beta > 1$) and negative under decreasing returns ($\alpha + \beta < 1$), as in the following proposition.

PROPOSITION 3. When price and marginal cost are equal, the covariance of the Solow residual with an instrumental variable will be positive under increasing returns to scale and negative under decreasing returns to scale.

To summarize: Competition and constant returns imply that the Solow productivity residual is uncorrelated with an exogenous instrumental variable. "Exogenous" means that the variable is neither a cause of productivity fluctuations nor a result of those fluctuations. In the presence of market power, the covariance of the Solow residual and the instrument will be positive, except under very unusual conditions. When an outside force causes output and employment to rise, the elasticity of the relation between the two variables will be greater than the observed factor share of labor. Too little weight will be given to the increase in labor input in the calculation of the Solow residual; it will record an increase in measured productivity. The same thing would happen in the unlikely case of increasing returns in the presence of price equal to marginal cost.

III. Value Added

In addition to the labor and capital considered in the previous section, firms use materials and other intermediate products as inputs to production. When time-series data on other inputs are available, it is a simple matter to add additional terms to equation (9), each containing a factor share multiplying a rate of growth of an input. But it is also possible to make use of annual data on nominal and real value added in place of full input-output data. This section modifies the earlier analysis to deal with that case. In this section, variables with asterisks signify measures of the theoretical ideal: Q^* is true gross output, q^* is the log of the ratio of Q^* to capital, p^* is the actual price of output, γ^* and α^* are the factor shares of materials and labor relative to the value of gross output, p^*Q^*, θ^* is the rate of Hicks-neutral technical progress in the production function relating gross output to all inputs, and μ^* is the ratio of the actual price to full marginal cost. Also, v is the price of materials, M is the quantity of materials employed, and m is the log of the materials/capital ratio. Then a simple extension of equation (9) shows how the hypothesis of competition could be tested in this setup:

$$\Delta q^* - \alpha^*\Delta n - \gamma^*\Delta m = (\mu^* - 1)(\alpha^*\Delta n + \gamma^*\Delta m) + \theta^*. \quad (19)$$

The left-hand side is the Solow residual generalized to include materials. The first term on the right-hand side shows that the Solow residual will be positively correlated with an exogenous instrument when the firm has market power, that is, when μ^* exceeds one. In the case at hand, the output measure that is available is not Q^*, gross output, but Q, real value added. In that case, the test based on the simple Solow residual, computed from real value added and employment growth, is a valid test. The rate of growth of the ratio of real value added to the capital stock is

$$\begin{aligned}\Delta q &= \frac{\Delta(Q/K)}{Q/K} = \frac{p^*\Delta(Q^*/K) - v\Delta(M/K)}{(p^*Q^*/K) - (vM/K)} \\ &= \frac{\dfrac{\Delta(Q^*/K)}{Q/K} - \dfrac{vM}{p^*Q^*}\dfrac{\Delta(M/K)}{M/K}}{1 - \dfrac{vM}{p^*Q^*}} \\ &= \frac{\Delta q^* - \gamma^*\Delta m}{1 - \gamma^*}.\end{aligned} \quad (20)$$

This relation can be used to eliminate the unobserved Δq^* from equation (19):

$$\Delta q - \alpha\Delta n = (\mu^* - 1)\left(\alpha\Delta n + \frac{\gamma^*}{1 - \gamma^*}\Delta m\right) + \theta. \quad (21)$$

Here α is the labor's share in value added and θ is the rate of technical progress stated in labor-capital augmenting form ($\theta = \theta^*/[1 - \gamma^*]$). Equation (21) says that the Solow residual calculated from value added will be equal to the rate of technical progress, appropriately defined, if and only if the firm is competitive, that is, μ^* is one. The covariance of the Solow residual with an exogenous instrument will be zero under competition and will be positive under market power. This statement is subject to the same minor qualifications stated in the previous section plus the additional one that the growth of material inputs, Δm, be positively correlated with the instrument. None of the instruments employed in this paper is likely to fail the latter requirement. One instrument—the rate of decline of the world oil price—is particularly suitable because its substitution effect adds to the impact in the appropriate direction.

The discussion in this section made the implicit assumption that the change in real value added was computed each year using the previous year's prices as the base prices (see eq. [20]). In effect, it assumed the use of a Divisia index of real value added. In the U.S. national income accounts, base prices are changed about once a decade. I know of no reason to think that the low frequency of base changes has any important influence on the results obtained by the technique in this paper.

IV. Choice of the Instrumental Variables

The instrumental variables for the test should cause important movements in employment and output but be uncorrelated with the random fluctuations in productivity growth. Such exogenous variables could operate through product demand or through factor supplies. Lack of correlation with the random element of productivity growth involves two considerations: First, the instrument must not cause movements in productivity, and, second, it must not respond to random variations in productivity growth.

It is a challenge to find instruments that are plainly exogenous under all views of macroeconomic fluctuations and that also have large enough influences on employment and output so that the test is powerful. Recent research has cast doubt on the exogeneity of all measures of monetary policy that are much correlated with output. On the fiscal side, only military spending is arguably unresponsive to the current state of employment and output. No single assumption is likely to appeal to all schools of thought about the relation between productivity growth and output fluctuations. Hence, I will present results for a variety of instruments, suggested by Valerie Ramey.

Military Spending

Military spending undergoes occasional large fluctuations that do not appear to be driven by the business cycle or by fluctuations in productivity. In addition, there is no reason to think that increases in government purchases of certain products should shift the production functions for the industries making those products, at least from one year to the next. Were military spending sufficiently correlated with employment and output, it probably would be the most persuasive instrument for the purposes of this paper. In addition to government purchases of goods, which operate through product markets, changes in military employment help identify the equation through fluctuations transmitted via the labor market.

The World Oil Price

It is reasonable to assume that the historical pattern of shifts in the world price of oil has not been caused in any important way by fluctuations in U.S. productivity growth. The other part of the argument supporting the rate of change of the oil price as an instrument holds that shifts in oil prices do not cause changes in productivity. That hypothesis is more controversial. Its justification is that changes in factor prices do not shift production functions in the short run. Under this hypothesis, the observed tendency for measured productivity to fall when oil prices rise is the result of the negative response of output to that rise.

The Political Party of the President

Systematic differences in economic policies of the two political parties have caused differences in rates of expansion of the industries considered here, both over time and across industries. Outputs of services, durables, and regulated industries have risen noticeably faster under Democrats than under Republicans. Under the reasonable hypothesis that neither party has adopted policies that affect productivity growth in the short run, this systematic difference can be used to test the joint hypothesis of competition and constant returns.

V. Econometric Method

Under the basic identifying hypothesis that true shifts in productivity are unrelated to movements of the instrumental variable, testing of the joint hypothesis of competition and constant returns is a simple matter of testing the hypothesis that the covariance of the Solow residual $\Delta q - \alpha\Delta n$ and the instrument Δz is zero. To the extent that periods in which outside forces raise output are periods in which the actual growth of output exceeds the amount expected from observations on the revenue share, α, applied to labor growth, Δn, the joint hypothesis is falsified.

Although the test could be conducted with the raw covariance itself, an equivalent and more easily interpretable test is based on the regression coefficient of the Solow residual on the instrument. Thus the tests to be employed are *t*-tests for the exclusion of the instruments from the regressions.

The test does not assume that the markup ratio, μ, is a constant. It is of interest, however, to gain some sense of the magnitude of the departure from competition. Estimates of μ based on the assumption of constancy are useful for this purpose. The estimate of μ obtained by applying instrumental estimation to equation (9) is

$$\hat{\mu} = \frac{\text{cov}(\Delta q, \Delta z)}{\text{cov}(\alpha \Delta n, \Delta z)}. \tag{22}$$

This estimator suffers from a subtle defect. When overhead labor and labor hoarding are extreme, employment growth Δn is hardly correlated with the instrument, even though output growth Δq is highly correlated. The resulting estimate, $\hat{\mu}$, is a large number. Moreover, the variance of $\hat{\mu}$ is large as well. Interpretation of the results is much enhanced by estimating the reciprocal, $1/\mu$. The reciprocal maps the entire region of values of μ greater than one into the interval from zero to one. The variance of the reciprocal is a much more informative measure of dispersion than the variance of $\hat{\mu}$ itself. With a single instrument, the instrumental estimator of the reciprocal is just the reciprocal of equation (22). With more than one instrument (the two-stage least squares estimator), the results are not invariant to the normalization. The reciprocal of the estimate and the estimate of the reciprocal are not exactly the same, but in practice the differences are usually very small.

VI. Data

I have obtained annual data for seven one-digit industry groups and 26 industries at roughly the two-digit level for the years 1953–84.[1] The industry detail is controlled by the labor input measure, which is an unpublished compilation of hours of work for all workers, including supervisory workers. The series are the following: Q: real value added, 1982 dollars (*U.S. National Income and Product Accounts* [NIPA]), K: net real capital stock (Bureau of Economic Analysis), p: implicit deflator with indirect business taxes removed (ratio of nominal value added less indirect business taxes to real value added), N: hours of work of all employees (NIPA), and w: total compensation divided by N.

Note that the data are chosen to eliminate tax wedges as a source of departures of marginal cost from price. The price level is measured net of sales and other taxes, and the wage is measured gross of social security, fringes, and other costs incurred by the employer. The in-

[1] The data are available from the author on diskette, together with a complete description of the sources.

dustries chosen were the most detailed for which the NIPA report hours of all employees.

The instrumental variables are the rate of increase of the world price of crude petroleum in dollars, the rate of growth of military purchases of goods and services in real terms, and a dummy variable with the value of one when the president is a Democrat and zero when he is a Republican.

VII. Results

Nondurables

Table 1 shows the construction of the Solow residual for nondurables. Figure 1 shows the evidence in the form relied on in this paper. The vertical axis plots the Solow residual, $\Delta q - \alpha\Delta n$. With equality of price and marginal cost, the residual should be unaffected by exogenous shifts in demand that cause both output and employment to rise. If marginal cost falls well short of price, then the increase in output will exceed the corresponding increase in employment multiplied by the share, α, because α understates the elasticity of output with respect to labor input. Hence a positive relation between the Solow residual and an exogenous demand variable is evidence that marginal cost falls short of price. The horizontal axis of figure 1 is the negative of the rate of growth of military spending. There is a positive relation between the Solow residual and the instrument. The explanation offered here is that the product wage understates the marginal product of labor; that is, price exceeds marginal cost.

The formal test discussed in Section IV confirms the findings of figure 1. The relation between the Solow residual and the instrumental variable, Δz, is

$$\underset{}{\Delta q - \alpha\Delta n} = \underset{(.004)}{.021} + \underset{(.064)}{.094}\Delta z, \tag{23}$$

standard error: 2.5%, Durbin-Watson statistic: 2.04.

Much stronger evidence against the joint hypothesis of competition and constant returns appears when the rate of change of the world price of crude oil is the instrument:

$$\Delta q - \alpha\Delta n = \underset{(.005)}{.029} + \underset{(.042)}{.110}\Delta z, \tag{24}$$

standard error: 2.1%, Durbin-Watson statistic: 1.88.

On the other hand, the covariance of the Solow residual for nondurables and the political dummy variable is very close to zero; nondurables employment and output are hardly affected by the party in power.

TABLE 1

Construction of the Solow Residual for Nondurables (Percentage Change)

Year	Output Growth Δq	Hours Growth Δn	Labor Share α	Weighted Hours Growth $\alpha\Delta n$	Solow Residual $\Delta q - \alpha\Delta n$
1953	1.31	−.47	.73	−.34	1.65
1954	−2.70	−6.33	.74	−4.67	1.97
1955	6.11	2.46	.71	1.75	4.37
1956	.40	−2.39	.72	−1.72	2.12
1957	−2.57	−4.84	.74	−3.60	1.03
1958	−.85	−5.04	.74	−3.74	2.89
1959	9.10	4.65	.72	3.34	5.76
1960	−.58	−1.90	.73	−1.39	.80
1961	.41	−2.66	.73	−1.95	2.36
1962	3.43	.05	.73	.03	3.40
1963	4.56	−2.38	.72	−1.71	6.27
1964	1.35	−2.15	.71	−1.53	2.89
1965	−.77	−2.96	.70	−2.08	1.32
1966	−2.18	−3.83	.70	−2.68	.50
1967	−6.29	−5.75	.71	−4.11	−2.19
1968	1.11	−2.91	.71	−2.07	3.17
1969	−1.24	−3.41	.73	−2.49	1.26
1970	−4.42	−7.84	.74	−5.77	1.35
1971	1.14	−4.95	.73	−3.60	4.74
1972	4.21	−.54	.73	−.39	4.61
1973	5.70	−.58	.73	−.42	6.12
1974	−11.37	−7.40	.75	−5.53	−5.83
1975	−6.01	−10.30	.69	−7.14	1.13
1976	5.66	1.37	.69	.95	4.71
1977	2.96	−1.24	.69	−.85	3.82
1978	.03	−1.33	.71	−.94	.98
1979	−.96	−2.85	.72	−2.05	1.09
1980	−6.34	−5.50	.73	−4.03	−2.31
1981	.65	−2.30	.71	−1.63	2.28
1982	−1.60	−7.52	.69	−5.22	3.61
1983	4.41	.91	.68	.62	3.78
1984	.47	1.20	.67	.81	−.34

Results for Seven Major Industry Groups

Table 2 presents the test statistics for seven major U.S. industry groups. The industries cover all private GNP except for mining and agriculture, where the role of natural resources is sufficiently high that important measurement issues arise in applying Solow's method. The table gives the marginal significance levels for a one-tailed t-test of the hypothesis of the exclusion of the instrument from a one-variable regression. The marginal significance level is the probability under the null hypothesis that the covariance would be at least as large as its observed value. Small values are evidence against the null

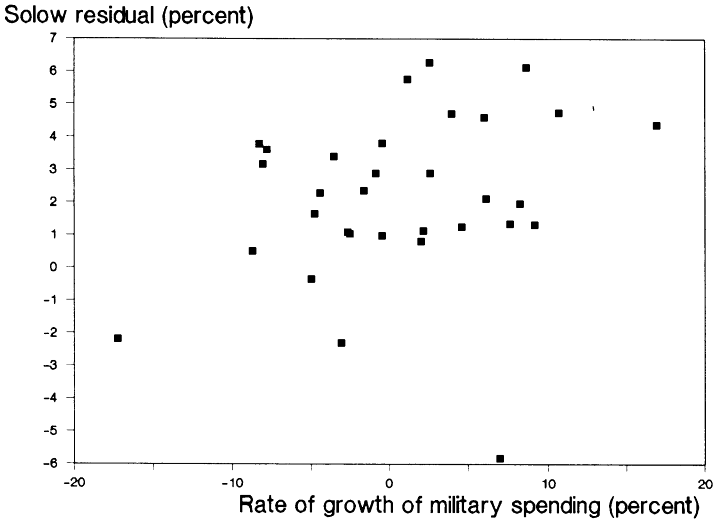

FIG. 1.—Solow residual for nondurables plotted against the rate of growth of military spending.

hypothesis and in favor of the alternative hypothesis of market power and increasing returns.

The rate of change of the world oil price provides the strongest evidence against competition. In five of the seven industries, the marginal significance level is under 3 percent: the observed covariance of the Solow residual and the instrument is extremely unlikely to have occurred because of chance alone. In one other industry, services, the marginal significance level is below 10 percent, which constitutes reasonably strong evidence against the null hypothesis in that industry as well.

TABLE 2

MARGINAL SIGNIFICANCE LEVELS FOR ONE-DIGIT INDUSTRIES

Industry	Military Spending	Oil Price	Political Party
Construction	.327	.003	.090
Durable goods	.500	.029	.357
Nondurable goods	.076	.001	.256
Transportation and public utilities	.079	.009	.363
Trade	.270	.002	.499
Finance, insurance, and real estate	.121	.271	.198
Services	.193	.082	.043

NOTE.—The table shows the marginal significance levels for a one-tailed test of the hypothesis that the covariance of the Solow residual and the instrument is positive. The sign of the instrument is normalized so that its covariance with output growth is positive.

Except in finance/insurance/real estate, episodes of oil price increases saw large reductions in output along with smaller reductions in labor input. Productivity fell dramatically. I believe that output and employment fell for some reason other than a downward shift in the production functions. I infer that the observed factor shares understate the true elasticity of output with respect to labor because prices exceed marginal costs.

The rate of change of military spending provides some evidence against the joint hypothesis of competition and constant returns in construction, nondurables (reviewed in detail in the last section), transportation, trade, finance/insurance/real estate, and services. It is interesting to note that military spending growth stimulates services but retards nondurables and construction. The raw covariances of military spending growth and the Solow residuals go in the same direction: military spending raises measured productivity in services and lowers it in nondurables and construction. In fact, the two covariances have the same sign in every industry except durables.

The political dummy yields reasonably strong evidence against competition in two industries, construction and services. In both, having a Democrat in power stimulates activity and raises measured productivity.

Results for Detailed Industries

Table 3 shows similar results for 26 more detailed industries, mostly at the two-digit Standard Industrial Classification (SIC) level. Again, the oil price instrument generates the most conspicuous evidence against the joint hypothesis of competition and constant returns: nine of the industries have marginal significance levels below 5 percent. The other two instruments bring rejections in a number of other industries as well.

I conclude that, under the assumptions stated at the outset of the paper and under the further assumption that all the variables are measured accurately, the evidence favors a certain amount of market power as against the hypothesis of pure competition. The response of productivity to outside events that themselves are unlikely to affect productivity or be affected by it cannot be explained under competition but has a ready explanation through market power.

Estimates of the Degree of Market Power under the Assumption of a Constant Ratio of Price to Marginal Cost

As I noted in Section IV, the most convenient way to measure the magnitude of market power under the assumption of a constant

TABLE 3

MARGINAL SIGNIFICANCE LEVELS: FURTHER INDUSTRY DETAIL

Industry	Military Spending	Oil Price	Political Party
20: Food and kindred products	.398	.023	.265
21: Tobacco manufactures	.087	.231	.366
22: Textile mill products	.253	.082	.170
23: Apparel and other textile products	.208	.614	.591
24: Lumber and wood products	.632	.250	.096
25: Furniture and fixtures	.043	.063	.447
26: Paper and allied products	.191	.004	.271
27: Printing and publishing	.068	.081	.500
28: Chemicals and allied products	.184	.001	.291
29: Petroleum and coal products	.053	.001	.425
30: Rubber and miscellaneous plastic products	.285	.237	.246
31: Leather and leather products	.141	.494	.161
32: Stone, clay, and glass products	.357	.002	.379
33: Primary metal industries	.155	.341	.221
34: Fabricated metal products	.265	.092	.304
35: Machinery, except electrical	.748	.065	.624
36: Electric and electronic equipment	.252	.027	.038
38: Instruments and related products	.478	.723	.362
39: Miscellaneous manufacturing industries	.452	.144	.075
48: Communication	.356	.216	.674
49: Electric, gas, and sanitary services	.440	.208	.202
371: Motor vehicles and equipment	.369	.124	.376
372–79: Other transportation equipment	.455	.557	.669
Transportation	.022	.020	.219
Wholesale trade	.270	.002	.283
Retail trade	.319	.013	.596

NOTE.—See note to table 2.

markup ratio, μ, is to estimate the reciprocal, $1/\mu$, which I will call β. It has the value one under competition and falls short of one to the extent that price exceeds marginal cost. Table 4 gives estimates of β with their standard errors for the one-digit industry groups. These estimates make use of all three instruments together by using the two-stage least squares estimator. For all seven industries, the estimate of β is significantly less than one, confirming the result of table 2 that the hypothesis of competition is rejected.

The estimated values of the markup ratio, μ, are shown in the last column of table 4. The interpretation of these estimates must heed the warnings of Section III with respect to the use of data on value added. The estimate of μ measures the ratio of price less materials cost (the valued added deflator) to marginal cost excluding marginal materials cost. Such an estimate always overstates μ^*, the ratio of price to full marginal cost. The estimates of μ in table 4 range from a little under 2 to a little under 4. That is, of the total value added per unit of sales, only 25–55 percent is marginal cost; the rest is earnings from

TABLE 4

ESTIMATES OF MARKUP RATIO AT ONE-DIGIT LEVEL

Industry	Estimate of Reciprocal, $\hat{\beta}$	Durbin-Watson Statistic	Markup Ratio, $\hat{\mu}$
Construction	.455 (.103)	1.051	2.196
Durable goods	.486 (.111)	1.942	2.058
Nondurable goods	.323 (.102)	2.081	3.096
Transportation and public utilities	.313 (.119)	1.570	3.199
Trade	.264 (.109)	1.474	3.791
Finance, insurance, and real estate	.303 (.167)	1.734	3.300
Services	.536 (.187)	1.662	1.864

NOTE.—$\hat{\beta}$ is the two-stage least squares estimator of $1/\mu$, with military spending, oil price, and the political dummy as instruments; $\hat{\mu}$ is its reciprocal. Standard errors are in parentheses.

market power. The deviations from invariance of the Solow productivity residual documented in table 2 correspond to economically significant amounts of market power.

Table 5 presents estimates of β and μ for the more detailed industries. Not every industry shows evidence of market power. For example, in apparel (SIC 23), $\hat{\beta}$ is slightly, but not significantly, greater than one. In three industries (petroleum, mining, and wholesale trade), the covariances of weighted employment growth, $\alpha\Delta n$, and output growth, Δq, with the instrument (a linear combination of the military, oil, and political instruments) have opposite signs, which creates a problem of interpretation, in principle. However, in all three, the covariance of the instrument with output growth is robustly nonzero and the covariance with employment growth is very close to zero. The most reasonable interpretation is that overhead labor and labor hoarding are important in these industries, which supports the conclusion that they are not competitive.

Subsequent Research

The results reported here are strongly confirmed by subsequent research in the framework developed here carried out by Domowitz, Hubbard, and Petersen (1988). They have a rich body of data on extremely detailed industries. The data report gross output and material inputs so that it is not necessary to work with value added. By pooling industries within two-digit categories, Domowitz et al. are

TABLE 5

ESTIMATES OF MARKUP RATIO: FURTHER INDUSTRY DETAIL

Industry	Estimate of Reciprocal, $\hat{\beta}$	Durbin-Watson Statistic	Markup Ratio, $\hat{\mu}$
20: Food and kindred products	.189 (.144)	1.301	5.291
21: Tobacco manufactures	.362 (.193)	1.476	2.766
22: Textile mill products	.388 (.160)	2.384	2.578
23: Apparel and other textile products	1.213 (.592)	1.911	.824
24: Lumber and wood products	.555 (.223)	2.013	1.801
25: Furniture and fixtures	.506 (.118)	1.990	1.977
26: Paper and allied products	.269 (.060)	1.948	3.716
27: Printing and publishing	.070 (.294)	.961	14.263
28: Chemicals and allied products	.050 (.067)	1.821	20.112
29: Petroleum and coal products	−.007 (.122)	1.432	−139.478
30: Rubber and miscellaneous plastic products	.663 (.249)	2.036	1.508
31: Leather and leather products	.476 (.337)	2.086	2.100
32: Stone, clay, and glass products	.394 (.090)	1.885	2.536
33: Primary metal industries	.460 (.100)	2.374	2.172
34: Fabricated metal products	.607 (.232)	2.478	1.649
35: Machinery, except electrical	.700 (.265)	.992	1.429
36: Electric and electronic equipment	.324 (.175)	2.284	3.086
38: Instruments and related products	.716 (.540)	2.558	1.397
39: Miscellaneous manufacturing industries	.223 (.130)	1.888	4.491
48: Communication	.028 (.998)	1.764	36.313
49: Electric, gas, and sanitary services	.079 (.290)	.389	12.591
371: Motor vehicles and equipment	.567 (.191)	3.218	1.763
372–79: Other transportation equipment	1.053 (.413)	1.679	.095
Transportation	.251 (.196)	2.743	3.976
Wholesale trade	−.271 (.366)	1.076	−3.688
Retail trade	.425 (.109)	2.253	2.355

NOTE.—See note to table 4.

able to achieve much greater power than the tests of this paper. They find extremely strong rejection of competition in most manufacturing industries.

Shapiro (1987), using data similar to those of this paper, extends this framework to estimate the elasticity of market demand jointly with the ratio of price to marginal cost. He confirms the basic finding of market power in numerous industries.

VIII. Possible Specification Errors

The basic empirical finding of this paper is that expansions in response to outside forces involve a much larger increase in output than what would be expected from the observed increase in labor input, on the basis of the use of labor's share as an estimate of the elasticity of output with respect to labor input. I offer the interpretation of this finding that the share understates the true elasticity because price exceeds marginal cost. However, the empirical finding can also be explained in a competitive setting through one or a combination of specification errors. For a much more detailed analysis of specification errors in this setting, see Hall (1987).

Variations in Work Effort and in Hours

Suppose that employees put in more work effort per hour when output and employment are higher. Suppose further that there is a disamenity of work effort that employers perceive as a cost. Then the method of this paper is biased toward rejecting competition. The omission of work effort from $\alpha\Delta n$ understates its value when it and Δq are positive and makes the residual larger than it should be. The residual will be positively correlated with an instrument that causes increases in output. Note that variations in effort that are costless to the firm (because there is no disamenity to the worker or because the disamenity is not passed on to the firm) do not cause any bias. It can be shown (Hall 1987) that the fluctuations in unobserved effort needed to rationalize all the correlation of the residual with the instruments are substantial, with fluctuations as large as 10 percent above normal in years of high output. Moreover, it is clear that workers are not compensated on a current basis for their increased effort. As it is, compensation per hour hardly changes when output changes. If times of high output are also times of high effort per hour and if compensation is paid for work in efficiency units, the wage per efficiency unit declines substantially when output rises. Thus unobserved fluctuations in work effort bias the test only if employers perceive added effort as costly but do not pay for the effort on a current basis.

Fluctuations in unmeasured work effort should not be taken for granted. Fay and Medoff (1985) found from a survey of employers that effort is slightly *negatively* correlated with output, not strongly positively correlated.

Measurement errors in hours of work could also explain the findings in a competitive setting if the errors are sufficiently negatively correlated with movements of output. Purely random errors in Δn, uncorrelated with the instrumental variable, do not bias the covariance. However, it is easy to think of reasons why the error would be negatively correlated. For example, suppose that some workers always report 40 hours of work per week even though they work more hours when demand is strong and fewer when it is weak, and employers perceive these extra hours as costly.

There are two important reasons to discount measurement errors in hours. First, the great bulk of variations in total hours arises from changes in the number of employees, not in the number of hours per employee. There is no obvious explanation for a negative correlation in errors in employee counts with the instruments. Second, the data used in this study take advantage of all available data on actual hours of work; the data are obtained from employers' payroll records for workers paid by the hour, and on hours reported by salaried workers in the *Current Population Survey*.

Cyclical Errors in Unrecorded Output

The hoarding of labor during cyclical contractions is probably an important element of the explanation of cyclical fluctuations in productivity. As I noted at the outset, the method of this paper properly adjusts for labor hoarding if it occurs in a competitive industry. However, labor hoarding could bring about a measurement error that would cause the method of this paper to overstate the extent to which competition fails to hold. Specifically, hoarded workers may be put to work on projects other than the production of measured output. They may repair equipment, build new facilities, train themselves or others, and engage in many other investment activities. Though the NIPA data attempt in principle to include these items in output, many are no doubt unmeasured. Fay and Medoff (1985) found that the increase in investment activities of workers idled by a slump was sufficient to explain an estimated markup ratio of no more than 1.1, far below the estimates for many industries found in this paper.[2]

[2] For details of this calculation, see Hall (1987).

Errors in Measuring Capital

Errors in measuring capital input sufficiently correlated with the instrument could cause the false rejection of competition. The dominant source of cyclical measurement errors is likely to be the difference between capital in use and capital available. The first is required by the theory, but the second is what is actually used in the calculations of this paper. The difference matters if the shadow value of capital remains positive in episodes in which firms are not using all their available capital. If some capital has gone out of use because it is redundant, there is no bias in the type of test used in this paper.

Capital will be taken out of use even when it has a positive shadow value if there is a pure user cost of capital, that is, a wearing-out cost avoidable by taking capital out of use. But even if the fraction of capital taken out of use in a slump is equal to the proportional decline in hours of work, the resulting estimate of the markup ratio in a competitive industry is only the reciprocal of labor's observed share, well below what is found in quite a few industries.

Capital can just as well have a negative shadow value in episodes when not all available capital is in use. Overhead labor technologies typically have this feature. When output falls below capacity, firms have to keep staffing their redundant capital with expensive overhead labor and would be better off if they could junk some of their capital temporarily. If such a firm does succeed in idling part of its capital, but the remainder still has a negative shadow value in a slump, then the bias will be toward, not away from, a finding of competition.

Cyclical Errors in Measuring Labor's Share

Errors in measuring the value of α that are correlated with the instrument but do not affect the mean value of α are benign in this framework. Examples of measurement errors with this character are (1) payment of workers under wage-smoothing arrangements, where the wage equals the long-run opportunity cost of time but does not track short-run fluctuations in labor market conditions; (2) adjustment costs in employment, where the full marginal cost of incremental hours of work fluctuates above and below the observed wage; and (3) price rigidity, where prices are set at the long-run average of marginal cost.

Under wage smoothing, workers receive less than their marginal products in good times and more in bad times. Hence the share α is understated in good times and overstated in bad times. When the instrument is positive and consequently output growth and employment growth are also positive, the Solow residual measured with too small an α is also positive. A positive term enters the covariance of the instrument and the residual. On the other hand, when the instrument, output growth, and employment growth are all negative, the Solow residual is positive as well: the term $-\alpha\Delta n$ is overstated in a positive direction because Δn is negative. A negative term enters the covariance of the instrument and the residual. In data with an approximately equal mixture of good and bad times, the covariance will turn out to be zero. That is, a competitive industry with wage smoothing will not generate data that reject the invariance property.

Adjustment costs in employment have the same character as wage smoothing. Half the time, the shadow cost of labor to the firm exceeds the wage, and the measured value of α understates the true value. These are times when the current change is in a direction that adds to adjustment costs. The other half of the time, the shadow cost of labor falls short of the wage because the current change in employment conserves adjustment costs. There is no bias in labor's share, α, in the long run, but there are measurement errors correlated with the instrument. But the errors cancel out, and there is no reason to expect to find a correlation of the Solow residual and the instrument in a competitive industry with labor adjustment costs.

Price rigidity could arise in a competitive industry if firms find it necessary to post prices before observing current demand. If firms stand ready to serve all demand, then the same type of symmetry prevails as that described earlier. When demand is strong, α is overstated because the pQ in the denominator understates the true value of output based on marginal cost. When demand is weak, α understates labor's share in marginal cost. But there is no resulting correlation of the Solow residual and an instrument correlated with demand. Rotemberg and Summers (1987) examine this case in more detail. They show that a positive covariance of the Solow residual and an instrument would arise if the firm's behavior is asymmetric, serving all demand in the low-demand states but rationing output if marginal cost exceeds the predetermined price.

IX. Interpretation and Conclusions

The basic fact found in this paper is neither new nor surprising. When output rises, firms sell the output for considerably more than they pay for the incremental inputs. Most economists have been content to invoke the idea of cyclical fluctuations in productivity in thinking about this fact. My point in this paper is that the fact may involve a dramatic failure of the principle that marginal cost is equated to price. Marginal cost is literally the increase in the cost of inputs needed to produce added output. That increase is small, so marginal cost is small. When it is compared to price, a large gap is found in many industries. The most obvious explanation of the finding of price far in excess of marginal cost is monopoly power in the product market. Since few American firms are simple monopolies, the finding probably requires an interpretation in terms of theories of oligopoly and product differentiation. Then the finding lends strong support to the view that these theories are more realistic than the simple theory of competition.

Departures from competition in the product market are not the only potential explanation of the finding of this paper. Monopsony in input markets is another possibility. For example, a monopsonist in the labor market faces a marginal cost of labor in excess of the wage it pays. In principle, a firm with sufficient monopsony power in the labor market but facing competitive conditions in its product market could have its price equal to its actual marginal cost, but well above the level inferred from the quoted wage in my calculations. However, I am not aware of any reason to think that monopsony in input markets is anywhere near pervasive enough to explain the findings. On the other hand, simple monopoly or more complicated types of monopoly power in labor or other input markets have no role in explaining the finding. In the labor market, all that is needed for my purposes is that the measured wage is the actual incremental cost of labor. Broader efficiency issues will rest on the question of whether the wage correctly values the forgone time of workers, but the narrow hypothesis that the firm is a price taker in input markets is all that is needed for measuring the price/marginal cost ratio.

All the findings of this paper can be interpreted as revealing imperfectly competitive markets only within the basic identifying hypotheses set forth at the beginning of the paper. The instruments are not causes of productivity shifts, nor are they influenced by those shifts. Labor input is measured reasonably accurately, including its effort as well as its hours dimension. Capital input is reasonably accurately measured, or its user cost is sufficiently low that measurement errors are irrelevant. I consider all these to be reasonable hypotheses. Consequently, I find the evidence against pure competition reasonably convincing.

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